PATENT

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UNITED STATES PATENT APPLICATION

FOR

EXPLOSION-PROOF INSTRUMENT QUICK DISCONNECT AND SEAL

ON BEHALF OF

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TITLE OF THE INVENTION

EXPLOSION-PROOF INSTRUMENT QUICK DISCONNECT AND SEAL

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 60/298,300, filed June 14, 2001.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to quick connectors/disconnectors for electrical circuits, and more particularly, to an explosion-proof instrument quick disconnect and seal for use in hazardous environments to quickly connect or disconnect electrical circuits.

2. Description of the Related Art

There are many applications today where electrical connections are made in hazardous (*e.g.*, explosive) environments, such as locations where ignitable concentrations of flammable gases, vapors or liquids are present or may become present through accident or abnormal operation. For instance, Article 500 of the National Electrical Code ("NEC") has classified certain locations as hazardous, including Class I (combustible material in the form of gas vapors) and Class II (combustible material in the form of dust).

In most modern industrial applications, electrical wiring/cable passes through a conduit system from location to location, such as from an enclosure housing of an electronic instrument to terminals in junction boxes outside the instrument or to the plant electrical and instrumentation distribution systems. Electrical circuits present certain inherent risks in hazardous environments because electrical sparks or arcing may occur when an electrical circuit is made or disconnect using a plug and receptacle due to the sudden flow or interruption of electrical energy. For this reason, NEC requires that conduit connections in certain hazardous environments be sealed with an approved explosion-proof seal fitting to prevent hazardous gases from traveling through the conduit system in the event of an internal explosion and to prevent a flame or an internal explosion from igniting the surrounding atmosphere.

In such hazardous environments, it is known to install explosion-proof seal fittings at various locations along the conduit system to prevent the passage of gases, vapors or flames from one portion of the electrical installation to another through the conduit. These conventional seal fittings typically have an opening through which a sealing compound or cement is introduced to literally seal the conduit and wire/cable contained therein at that location. However, these seal fittings are expensive and their installation is labor intensive. Furthermore, removal of the seal (*e.g.*, for maintenance or service of the electrical system) is exceedingly difficult and typically requires either cutting the seal fitting off of the conduit system (which may also result in cutting the wire/cable contained therein) or chipping away the sealing compound contained within the fitting.

Accordingly, it is desirable to have a device for quickly connecting or disconnecting live electrical circuits in indoor and outdoor hazardous areas that includes an explosion-proof seal for preventing hazardous gases, vapors or liquids from traveling through the conduit system in the event of an internal explosion and to prevent a flame or internal explosion from igniting the surrounding atmosphere.

SUMMARY OF THE INVENTION

These and other objects of the present invention are accomplished through the use of an explosion-proof instrument quick disconnect to be used in hazardous (*e.g.*, explosive) environments to quickly connect or disconnect energized or de-energized electrical circuits. The device also acts as an explosion-proof conduit seal in which a sealing compound is poured through the ends where wire/cable exits the connector, therefore meeting the requirements of the NEC and eliminating the need for separate seal fittings surrounding the device.

The explosion-proof instrument quick disconnect and seal comprises a first portion having a first bore extending therethrough from a proximal end to a distal end. A second portion is detachably coupled to the first portion and has a second bore extending therethrough from a first end to a second end. The second end of the second portion is received within the first bore of the first portion to define an explosion-proof chamber within the first and second portions when the first and second portions are coupled to one another. First and second electrical inserts, each having electrical contacts, are positioned within the first bore of the first portion and second bore of the

second portion, respectively. Each of the electrical contacts in the first electrical insert engage and form an electrical connection with a respective electrical contact in the second electrical insert within the explosion-proof chamber when the first and second portions are coupled to one another.

The foregoing specific objects and advantages of the invention are illustrative of those that can be achieved by the present invention and are not intended to be exhaustive or limiting of the possible advantages which can be realized. Thus, these and other objects and advantages of this invention will be apparent from the description herein or can be learned from practicing this invention, both as embodied herein or as modified in view of any variations which may be apparent to those skilled in the art. Accordingly, the present invention resides in the novel parts, constructions, arrangements, combinations and improvements herein shown and described.

BRIEF DESCRIPTION OF DRAWINGS

The foregoing features and other aspects of the invention are explained in the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is a cross-sectional view of a partially assembled explosion-proof quick disconnect and seal in accordance with a preferred embodiment of the present invention;

FIG. 2 is a side elevational view of the female end of the explosion-proof quick disconnect and seal illustrated in FIG. 1;

FIG. 3 is a cross-sectional view taken along line 2–2 of the female end illustrated in FIG. 2;

FIG. 4 is a side elevational view of the male end of the explosion-proof quick disconnect and seal illustrated in FIG. 1; and

FIG. 5 is a cross-sectional view taken along line 4–4 of the male end illustrated in FIG. 4.

DETAILED DESCRIPTION

In accordance with the present invention, an explosion-proof instrument quick disconnect and seal is provided for use in hazardous (*e.g.*, explosive) environments to quickly connect or disconnect energized or de-energized electrical circuits. A preferred embodiment of the present invention is described below with reference to the drawings.

Referring to FIG. 1, there is shown an assembled explosion-proof instrument quick disconnect and seal **10** in accordance with a preferred embodiment of the present invention. The quick disconnect and seal **10** includes two mating portions, a female portion **20** and a male portion **30**, which, as discussed below, are designed to be readily coupled to and, alternatively, separated from one another.

The female portion **20** of the explosion-proof instrument quick disconnect and seal **10** is best illustrated in FIGS. 2 and 3. The female portion **20** includes a generally cylindrical body **21** having a bore **22** therethrough extending along a longitudinal axis between a proximal end **23** and a distal end **24** of the body **21**. The body is preferably made from stainless steel or other suitable materials to

withstand potential explosive forces should gases or vapors ignite within the explosion-proof instrument quick disconnect and seal **10**, as well as to resist oxidation or corrosion when exposed to the hazardous environment.

Preferably, the bore **22** is enlarged near the proximal end **23** of the body **21** for receiving a female electrical receptacle insert **26**, which is preferably seated on a lip or flange **15** within the bore **22**. The receptacle insert **26** may be secured within the bore in a conventional manner, such as through the use of flexible tabs projecting from the insert that are compressed by the wall of the bore **22** when the insert **26** is positioned within the body **21**. Other conventional arrangements for securing the insert **26** within the body **21** are suitable for use with the present invention.

The receptacle insert **26** is preferably made of a non-electrically conductive material (*e.g.*, plastic) and includes a plurality of female sleeves extending longitudinally therethrough. As will be discussed further below, the female sleeves, which are made from an electrically conductive material such as a gold plated copper alloy, have an opening on one end for receiving electrically conductive male pins **38** projecting from a male insert **36** retained in the male portion **30**. Conventional electrical inserts **26, 36** may be used in accordance with the present invention, such as Circon R2.5 Series Circular Connectors.

As best illustrated in FIG. 3, the electrically conductive sleeves are electrically connected in a conventional manner (*e.g.*, by crimping or soldering) to electrical conductors **12** (e.g., wires, cables, *etc.*) within the bore **22** of the body **21**, which conductors **12** extend from the distal end **24** of the body **21** for connection to

external circuits.

A union or swivel nut **40** is provided on the distal end **24** of the body **21** to facilitate connection of the explosion-proof instrument quick disconnect and seal **10** to an adjoining conduit system (not shown) through which the conductors **12** may extend for connection to external circuits. The union **40** has a longitudinal bore extending therethrough such that the union **40** may be slid over and rotatably secured to the distal end **24** of the body **21**. The union **40** is preferably slid over the distal end **24** of the body **21** until a proximal end **41** of the union engages a shoulder **27** formed on the exterior of the body **21**. A retaining ring **45** may be positioned within a groove formed in the exterior of the body **21** near the distal end **24** to ensure that the union **50** does not separate from the body **21**.

The exterior of the union **40** is preferably formed with external (male) threads **42** to facilitate connection to an adjoining conduit system (not shown) having internal (female) threads for engagement with the external (male) threads of the union **40**. Other conventional arrangements for connecting the female portion **20** to an adjoining conduit system are also applicable with the present invention.

The union **40** is preferably made of stainless steel or other suitable materials to withstand potential explosive forces should gases or vapors ignite within the explosion-proof instrument quick disconnect and seal **10**, as well as to resist oxidation or corrosion when exposed to the hazardous environment. An O-ring **43** or other suitable gasket is preferably positioned within a groove formed within the bore of union **40** to form a seal between the union **40** and the body **21**, thereby preventing

gases or vapors from the atmosphere (hostile environment) from passing between the union **40** and body **21** into the conduit system, and also helping to make the explosion-proof instrument quick disconnect and seal **10** watertight.

The female portion **20** of the explosion-proof instrument quick disconnect and seal **10** also includes a cylindrical coupling nut **50** having a bore extending longitudinally therethrough. The coupling nut **50** preferably includes an inwardly extending flange **51**, which engages a shoulder **28** formed on the exterior of the body **21** when the body is received within the bore of the coupling nut **50**. In this manner, the coupling nut **50** may be rotatably positioned about the circumference of the body **21**. A retaining ring **54** may be positioned within a groove formed in the exterior of the body **21** to ensure that the coupling nut **50** does not separate from the body **21**.

As will be discussed further below, the coupling nut **50** is provided with internal (female) threads **55** within its bore for threadingly engaging external (male) threads **37** formed about the exterior of the male portion **30**. The coupling nut **50** is preferably made from stainless steel or other suitable materials to withstand potential explosive forces should gases or vapors ignite within the explosion-proof instrument quick disconnect and seal **10**, as well as to resist oxidation or corrosion when exposed to the hazardous environment. Referring to FIG. 2, the exterior of the coupling nut is preferably knurled to facilitate gripping by a user to manually rotate the coupling nut **50** to either connect or disconnect the female and male portions **20, 30**.

A male portion **30** of the explosion-proof instrument quick disconnect and seal **10**, which mates with and connects to the female portion **20**, is best illustrated in FIGS. 4 and 5. The male portion **30** is generally cylindrical in shape, having a bore **32** therethrough extending along a longitudinal axis between a proximal end **33** and a distal end **34** of the male portion **30**. Like the female portion **20**, the male portion **30** is preferably made from stainless steel or other suitable materials to withstand potential explosive forces should gases or vapors ignite within the explosion-proof instrument quick disconnect and seal **10**, as well as to resist oxidation or corrosion when exposed to the hazardous environment.

Preferably, the bore **32** is enlarged near the proximal end **33** of the male portion **30** for receiving a male electrical receptacle insert **36**, which is preferably seated on a lip or flange **35** within the bore **32**. The male receptacle insert **36** is designed to mate with and electrically connect to the female receptacle insert **26** of the female portion **20** when the male and female portions **20, 30** are fully connected to one another. The male receptacle insert **36** may be secured within the bore **32** in a conventional manner, such as through the use of flexible tabs projecting from the insert that are compressed by the wall of the bore **32** when the insert **36** is positioned within the male portion **30**. Other conventional arrangements may be used to secure the male receptacle insert **36** within the male portion **30**.

The male receptacle insert **36** is preferably made of a non-electrically conductive material (*e.g.*, plastic) and includes a plurality of electrically conductive pins or male contacts **38** that extend longitudinally through the insert **36** and project

therefrom. The pins **38**, which are made from an electrically conductive material, such as a gold plated copper alloy, are positioned such that each pin will engage and be electrically connected to a mating female sleeve in the female insert **26** when the male and female portions **20, 30** are properly aligned and fully connected to one another.

As best illustrated in FIG. 5, the electrically conductive pins **38** are electrically connected in a conventional manner (*e.g.*, by crimping or soldering) to electrical conductors **12a** (e.g., wires, cables, *etc.*) within the bore **32** of the male portion **30**, which conductors **12a** extend from the distal end **34** of the male portion **30** for connection to external circuits (*e.g.*, a terminal strip within an enclosure for an electronic instrument). The male portion **30** is preferably connected to an electrical apparatus, conduit system or electrical enclosure, where the current path is in a direction from the female portion **20** to the male portion **30**.

A conduit system (not shown) is removably connected to the distal end **34** of the male portion **30** through which the conductors **12a** may extend for connection to external circuits. Preferably, the distal end **34** of the male portion **30** is provided with external (male) threads **37a** to facilitate connection to the adjoining conduit system (not shown) having internal (female) threads for engagement with the external (male) threads **37a** of the male portion **30**. Other conventional arrangements for connecting the male portion **30** to an adjoining conduit system are also applicable with the present invention.

The proximal end **33** of the male portion **30** is also provided with external (male) threads **37** for threadingly engaging the internal (female) threads **55**

formed within the interior of the coupling nut **50**. The inside diameter of the bore **32** about the proximal end **33** of the male portion **30** is sufficiently large to permit the proximal end **33** of the male portion **30** to be slid over the proximal end **23** of the female portion **20**. However, the gap between the exterior wall of the proximal end **23** of the female portion **20** and the inside wall of the proximal end **33** of the male portion **30** should have very close tolerances (*e.g.*, 0.002 inch) and should preferably meet the requirements of the NEC and testing agencies, such as Underwriters Laboratories ("UL") and Factory Mutual ("FM"). This gap is the path through which the hot gases or flames, produced by an internal explosion, may escape, and is known as the "flame path."

An O-ring **25** or other suitable gasket is preferably positioned within a groove formed within the exterior of the body **21** to form a seal between the male portion **30** and the body **21**, thereby preventing gases or vapors from the atmosphere (hostile environment) from passing between the body **21** and the male portion **30** into the conduit system, and also helping to make the explosion-proof instrument quick disconnect and seal **10** watertight.

The outside diameter of the proximal end **33** of the male portion **30** is sized to permit the (male) threads **37** to threadingly engage the internal (female) threads **55** formed within the interior of the coupling nut **50** when the male and female portions **20, 30** are brought together. Thus, rotation of the coupling nut **50** will cause the internal (female) threads **55** to engage the external (male) threads **37** on the male portion **30** to thereby move the male portion **30** longitudinally relative to the female

portion **20**, while at the same time preventing the electrical connection of the receptacle insert **26** in the female portion **20** and male insert **36** in the male portion **30** before the explosion-proof chamber is secure.

As the coupling nut **50** is rotated (*e.g.*, in a clockwise direction), the male and female portions **20, 30** of the quick disconnect and seal **10** advance toward one another by thread engagement. In the preferred embodiment, the male and female receptacle inserts **26, 36** are positioned within the male and female portions **20, 30** at a distance requiring approximately five threads of travel before electrical connections are made between the two mating receptacle inserts **26, 36**. Thus, in the event of an internal explosion caused by arcing of the electrical contacts, five threads will be enough to prevent the male and female portions **20, 30** from separating and flying apart due to the pressure build up of the explosion. This number of threads will ensure that the minimal flame path length is also met.

Accordingly, in the preferred embodiment, when approximately five threads are engaged between the male portion **30** and coupling nut **50**, the male insert **36** and female receptacle insert **26** have preferably traveled toward one another to the point where the two mating electrical inserts **26, 36** are about to make electrical contact. At this point, the "flame path" length is preferably no less than ¾ inch, and the male and female portions **20, 30** are firmly held together by the coupling nut **50**. Additional rotation of the coupling nut **50** will fully engage the pins **38** of the male insert **36** within the sleeves of the female receptacle insert **26**, thereby making good electrical contact.

The process works in reverse to disconnect the electrical circuit. That is, the coupling nut **50** may be rotated (*e.g.*, in a counterclockwise direction) to separate the male and female portions **20, 30** and disconnect the circuit. In the preferred embodiment, when approximately five threads remain engaged between the coupling nut **50** and the male portion **30**, the pins **38** in the male insert **36** are about to exit from the mating sleeves of the female receptacle insert **26**, thereby breaking the electrical contact. At this point, the "flame path" is preferably no less than ¾ inch, and the male and female portions **20, 30** remain firmly held together by the coupling nut **50**, preferably by no less than five threads. Further rotation of the coupling nut **50** and associated thread disengagement will completely separate the pins **38** in the male insert **36** from the mating sleeves in the female receptacle insert **26**, and additional rotation of the coupling nut **50** will release the mechanical connection between the male and female portions **20, 30** so that they may be pulled apart and separated from one another.

As a safety precaution, it may be preferable that one of the pins **38** in the male receptacle insert **36** be longer than the remaining pins **38**. This longer pin (not shown) will preferably serve as a ground pin to ensure that the quick disconnect and seal **10** is properly grounded before electrical connection of the remaining pins **38** in the male insert **26** with the mating sleeves in the female receptacle insert **26**, as well as to ensure that the quick disconnect and seal **10** remains grounded up to the point of complete electrical disconnection of the remaining pins **38** in the male receptacle insert **36** from the mating sleeves in the female receptacle insert **26**.

To facilitate proper alignment of the male and female portions **20, 30**, an alignment pin or key **39**, preferably made from stainless steel or some other suitably hard material, is preferably used in conjunction with a hole or key way **29** formed in the proximal end **23** of the female portion **20** to assure that the insertion of the female portion **20** within the male portion **30** is only possible when the pins **38** in the male insert **36** are properly aligned with the mating sleeves in the female receptacle insert **26**. In the preferred embodiment, the hole **29** in the proximal end **23** of the female portion **20** acts as a keyway for the alignment key or pin **39** in the mating male portion **30** of the connector **10** to accurately align the male and female portions **20, 30** together. The alignment key or pin **39** and key way **29** ensure that the male and female portions **20, 30** of the connector **10** will mate properly. Because the pin **39** is preferably outside of the explosion proof chamber where the receptacle inserts **26, 36** engage, tolerances are not critical, thereby reducing manufacturing costs and making the connector **10** less prone to damage from rough handling during installation. This preferred arrangement is an improvement over the commonly used key system consisting of a channel or key way and a key, since a small burr or deformation in the key or key way will damage the device due to the close tolerances imposed by the explosion-proof services requirements.

In the preferred embodiment, the opening in the distal end **24** of the body **21** through which the electrical conductors **12** exit from the female portion **20** is completely sealed by preferably injecting a potting compound or sealing cement (not shown) into the opening and within the bore **22** surrounding the electrical conductors

12. Indentations, grooves or threads **60** in this area within the bore **22** of the body **21** are preferably provided to permit the potting compound or sealing cement to fill the indentations, grooves or threads **60**, thereby increasing the holding strength of the potting compound or sealing cement.

Similarly, in the preferred embodiment, the opening in the distal end **34** of the male portion **30** through which the electrical conductors **12a** exit is completely sealed by preferably injecting a potting compound or sealing cement (not shown) into the opening and within the bore **32** surrounding the electrical conductors **12a**. Indentations, grooves or threads **61** in this area within the bore **32** are preferably provided to permit the potting compound or sealing cement to fill the indentations, grooves or threads **61**, thereby increasing the holding strength of the potting compound or sealing cement.

Although an illustrative preferred embodiment has been described herein in detail, it should be noted and will be appreciated by those skilled in the art that numerous variations may be made within the scope of this invention without departing from the principle of this invention and without sacrificing its chief advantages. The terms and expressions have been used herein as terms of description and not terms of limitation. There is no intention to use the terms or expressions to exclude any equivalents of features shown and described or portions thereof and this invention should be defined in accordance with the claims that follow.